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A complete Table of Contents will appear in the last section of the booklet which will run in the June 1987 issue of CED.

Chapter One: Overview and Tutorial

Introduction

In past years, the connection of subscribers to a cable system was a simple matter of a matching transformer and, occasionally, a splitter to feed a second set. The FCC set up straightforward rules governing the technical specifications of the signal at the interface that would assure adequate quality reception. Recently, however, this interface has become very complex with the consumer electronics industry and the cable industry each trying to offer customers new features and solutions to problems caused by last year's new features. Increased tuning ranges, multiple premium service levels, remote controls and stereo sound, for instance, have all added to the interconnection problem.

The most dramatic development in home video equipment has undoubtedly been the video cassette recorder (VCR). To the consumer it offers much more than the capability of playing back pre-recorded tapes. It also offers the capacity for time shifting, recording material at will, simultaneous access to material on different channels, and numerous special effects that can be applied to recorded material, including "zapping" of commercials. Not only the cable industry, but the broadcasters and movie theaters have been drastically affected by its widespread market acceptance.

Of all the new consumer electronics developments, the VCR presents the greatest challenge to the cable television technical community. Most VCR's contain their own tuners, VHF modulators and a means for time-programming to allow unattended recording of a series of events on different channels. Connection to a cable system in such a way as to not lose any of these features is not simple!

This document will discuss problems of consumer equipment interconnection in detail, the technical requirements for a solution, and approaches to solutions using both discrete components and integrated switching systems. It is hoped that cable system operators will find the material useful in training of technical personnel and that manufacturers will find it useful as an aid to specifying designs for new consumer video products.

Scope of the Subcommittee's work

In January of 1985, the NCTA Engineering Committee proposed forming a subcommittee to examine short-term solutions to consumer interconnection issues. This effort was intended to complement the work of various other industry groups which are outlined in Appendix A, submitted by Walt Ciciora who chairs the EIA/NCTA Joint Engineering Committee and who has long been an industry leader in such matters, and by Judson Hofmann who served on the EIA Home Bus Committee. A few of these other groups are:

- The EIA/NCTA Joint Engineering working groups which are attempting to better define the electrical characteristics of the cable/consumer interface as a guide for future designs and operator practices.
- The EIA Decoder Interface Committee which is specifying a "universal" decoder interface jack for television sets and VCR's for use by post-detection descramblers.
- The EIA Home Bus Committee which is studying various communication needs within the home, including control of television equipment.

At its meeting in March, the subcommittee narrowed the scope of its investigation to the issues related to: VCR's, "Cable-Ready" television sets, Second sets in a single household, RF switching equipment, and Set-top descramblers.

Issues which were not considered, at least at this time, were two-way systems, off-premises equipment, stereo sound and baseband audio and video interconnections. Of these, the latter may be the most significant since many VCRs, an increasing number of TVs, and some converters contain such connections and they may be used in ways to both improve picture and sound quality and overcome some of the interconnection problems.

Aside from the switching features of various interconnection schemes, a major consideration is overall shielding effectiveness. Ingress from strong local television and communications radio stations may seriously degrade cable signals while egress from subscribers' terminal equipment will add to cable operators' leakage woes. Section I, chapter three, submitted by Joe Van Loan of Viacom, is a detailed treatment of those issues.

Acknowledgements

One paper in Section II, chapter three dealing with master-slave descramblers was authored by James Cherry and Tony Chen-tung Li and was presented earlier as an NCTA technical paper.

Obviously a great deal of work went into the illustrations of this document. We are indebted to Pan King of Jones Intercable for the diagrams in Chapter two and to Gloria Cook of Gill Cable for the bulk of the remaining artwork and for manuscript preparation and numerous editing sessions.

Although not individually noted, many members of the subcommittee and of the NCTA Engineering Committee made suggestions which have been incorporated with the intent of increasing the accuracy and readability of the final product.

Acronyms, Abbreviations

CSR	customer service representative
dB	decibel
dBmV	a signal level measurement expressed in decibels relative to 1 millivolt rms in a 75 ohm system

EIA	Electronic Industries Association
FCC	Federal Communications Commission
FM	frequency modulation
IR	infrared
MHz	megahertz
MSO	multiple system operator
nm	nanometer
OSI	open system interconnect
POS	position

Review of FCC Technical Standards

A major part of the FCC's technical rules for cable television (Part 76, Subpart K) are related to specifying the characteristics of the signal presented to the customer's television set. The principal ones that concern us here are:

- The signal level (75 ohm) shall be a minimum of 0dBmV but below "overload" level.
- The signal level of adjacent channels shall be within 3 dB and all channels shall be within 12 dB.
- The visual carrier-to-noise ratio shall be greater than 36 dB.
- The level of intermodulation products shall be at least 46 dB below visual carrier level.
- The leakage of cable signals shall be less than 15 microvolts/meter as measured at 100 feet and, in the range from 54 to 216 MHz, shall be less than 20 microvolts per meter as measured at 10 feet.

Note that, although these requirements (except for signal leakage) apply only to broadcast signals and are no longer enforceable at the federal level, they still have a sound technical basis.

These rules were promulgated in a much simpler time when "subscriber terminal equipment" meant one, or perhaps two, television sets whose tuning ranges were limited to the standard broadcast channel allocations. In recognition of a changing situation, the EIA/NCTA Joint Engineering Committee has drafted a Proposed "CATV RF Specification for Television Receiving Devices" which is currently in the approval process by the parent organizations. This standard would augment the FCC rules to the following degree:

- In order to prevent front-end receiver overload, the maximum video carrier level should be limited to +20 dBmV.
- Channels using the same frequencies on different cables of dual cable systems should have the RF carriers phase locked together to reduce the visual effects of co-channel interference. Levels of equivalent channels should be matched within 5 dB.
- Any video equipment which is designed to "loop-through" the RF carrier (such as a VCR's "bypass" mode) should have a loss of less than 5 dB.
- Any RF selection switches contained in video equipment should have an isolation of at least 70 dB through 216 MHz and 60 dB above that.
- Any video equipment with an RF input port should meet the requirements of Part 76 with respect to the re-radiation of cable signals and should, further, have a non-visible

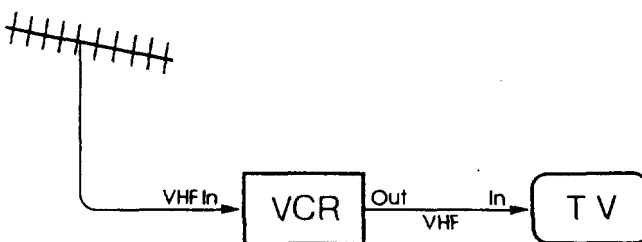
level of picture degradation when operated in external fields of up to one volt per meter from local VHF television stations.

• In recognition of the splitting losses required for multiple terminal equipment, cable systems are advised that in future designs, levels of at least +5 dBmV should be provided at the first terminal equipment connection point.

Although these latter requirements do not have the force of law, even if accepted by the organizations involved, they are a fair representation of the performance levels that will be required in today's complex home video environment.

Technical Requirements for a Solution

A simple off-air connection of a VCR and television set is shown below. This connection allows for simultaneous multichannel access, timed recording of events on different channels, and tape playback, all without any switching of cables. More elaborate installations may allow for tape-to-tape copying, FM receiver interconnections, external sound



amplification or additional video sources.

The ideal solution for cable operators would allow the greater programming selection of cable without adding cost, picture degradation or operating complexity and without loss of features or an increase in signal leakage. None of the solutions presented here meet all of those requirements, though all present partial solutions which may be adequate in specific situations.

Before considering overall solutions, individual component requirements will be examined:

Switching Isolation:

In a typical non-cable installation, the output modulator of the VCR is set to a channel that is not used by a local broadcast station. Since that removes any possible co-channel interference situations, switch isolation does not have to be particularly high. A typical cable connection, on the other hand, will very likely have a cable channel, the converter output and the VCR output all on the same channel, usually channel 3 or 4. Furthermore, none of these sources are locked together. Under those situations, it is necessary to assure that the ratio of desired to undesired video carriers be at least 65 dB at the input port of any demodulating device. Since the levels of the various sources will typically be within a 10 dB window, a conservative specification for an RF selection switch's on-off insertion loss ratio would be 75 dB at frequencies at or below channel 4. Should one of the input sources be an external antenna, the variation in expected signal ranges would be higher and the suggested specification is 80 dB through 216 MHz.

which is still below the specified performance of A-B switches used by the cable industry today. At other frequencies, generally the only co-channel situation occurs when selecting cables in a multi-cable system. If the opposing channels are phase-locked together an on-off ratio of 60-70 dB is adequate to assure non-degraded reception and to preserve the A-B isolation of the distribution system.

Losses and Amplification:

Although practices vary, many cable systems have been designed to deliver signal levels in the 0 to +3 dBmV range since that is adequate for simple television connection and higher levels add to the cost of plant construction and increase amplifier cascades.

Assuming a noise-free transmission network, the maximum attainable equivalent video carrier to noise ratio is:

$$C/N = 59 - NF + \text{Level}$$

where: C/N is the ratio of a noise-free incoming video carrier to the sum of thermal and internal noise sources measured in a 4.0 MHz bandwidth, NF is the terminal equipment noise figure in dB, and Level is the carrier level at the input terminals in dBmV.

Thus, if a converter has a noise figure of 11 dB and is driven with a 0 dBmV signal, the maximum attainable C/N is 48 dB. The noise of the signal processing equipment and transmission system will combine with this noise to determine the final video signal to noise ratio. If the terminal signal level is below 0 dBmV, the maximum attainable noise performance will vary accordingly and the converter will play an increasingly large part in determining overall noise level. Aside from FCC requirements, 0 dBmV was chosen as a compromise such that, in general, subscriber terminal equipment is not the dominant factor in total noise contribution.

In addition to the detrimental viewing effects of excess noise, low signal levels may interfere with proper operation of addressable devices and operation of teletext decoders and similar equipment. Typically, such equipment is specified for proper operation down to 0 dBmV only.

Thus, switching and splitting networks which result in more than minimal losses to the signal paths can result in noisy pictures at least and possibly improper operation of such devices as addressable descramblers. How much loss is too much will depend on drop levels in any given system.

To the extent that losses cannot be minimized by innovative circuit design, they may be overcome by amplifiers placed in some of the input or output ports of the switching network or, in some cases, by selectively changing customer tap levels or replacing RG-59 drop cable with RG-6. Section II, chapter one discusses more thoroughly the tradeoffs involved in adding amplification to such networks.

Shielding Requirements:

Any subscriber interconnection network should meet the requirements set forth in the proposed EIA/NCTA

guidelines. Section I, chapter three deals with the mechanisms involved and methodology for minimizing both ingress and egress. Under current FCC regulations, cable operators have responsibility for total leakage of cable signal from their franchise areas even though some of the leaking equipment may be subscriber-owned. These requirements are detailed in FCC rule paragraph 76.611 as amended October 26, 1984 and are commonly known as Composite Leakage Index or CLI.

In discrete-component arrangements of splitters and A-B switches, the major contributor to leakage is liable to be the quality of F-connector installation and the tightness of the fittings. Such factors should be considered if the operator chooses to let the subscriber take the major responsibility for installation of networks.

Packaged networks generally have fewer external connections, but the added requirement of total shielding over the switching components. While Federal rules regarding the signal leakage requirements for various classifications of subscriber terminal equipment are currently under review, some currently available networks are rather poorly shielded.

In any case, operators should educate both customers and installers as to the importance of good connections. Aside from external leakage and ingress considerations, poor shielding and leaky cables will detract from the isolation of non-selected RF sources and cause co-channel interference.

Security Factors:

Much of the dissatisfaction with the connection options offered to customers by cable systems is related to converter/descramblers. They are used to convert a spectrum of input channels to a common output channel and to descramble selected premium services. The problem is that they only deliver a single channel at a time so that recording one channel while watching another is impossible, particularly if both channels are scrambled.

Some of the solutions that are being considered address this issue by using multiple descramblers to simultaneously deliver all subscribed services. While this may offer subscriber convenience the operator should evaluate potential revenue losses due to:

- Second descramblers offered at reduced rates being transported to other subscribers homes as primary units.
- "Backyard" interconnects with multiple descrambled services delivered to non-subscriber's homes or apartments by coaxial cable.
- Cost associated with more elaborate descrambling hardware.

Chapter Two — A/B Switch Solutions

Discussion

The lowest cost and easiest to implement method of overcoming some of the feature limitations of converter/VCR interconnections is through the use of A-B switches and splitters. The advantages are that typically both are available to the operator with excellent specifications and

at relatively low cost. Also, they may be arranged in a variety of ways to solve specific situations.

On the negative side, even relatively complex networks do not give all the desired flexibility while the array of unlabeled, identical, A-B switches is both messy and confusing for the subscriber and can result in the loss of remote control capabilities. In addition component signal losses can degrade system performance.

Given the ready availability on the market of good, integrated switching networks for reasonable prices, we would expect that the use of discrete switching networks will decline rapidly. A packaged switching network which follows the suggested configuration of Section II is superior in nearly every respect to any of the discrete networks discussed below.

Below is a summary of possible configurations together with a summary of the capabilities of each to allow a logical choice to be made for a particular situation. The material presented was gathered from submissions by over 20 MSO's, independent operators, and manufacturers. Al Kernes of Jones and a working group of the Denver-based subcommittee members took on the task of redrafting the diagrams from the submitted suggestions.

How to use this guide

The 27 illustrations included in this chapter are arranged (for the most part) in ascending order of complexity. The first few installation set-ups depicted are the least expensive to install and the easiest for a subscriber to use. Unfortunately, the configurations that are least likely to confuse subscribers are the same ones that can limit the subscribers' ability to take advantage of features in their televisions or VCRs. Some subscribers may prefer to lose some remote control or VCR flexibility in favor of simplicity of operation, others may not. The selection guide summarizes installation trade-offs.

You will need to keep these factors and their relative importance in mind when choosing a configuration:

- simplicity of operation
- ability to use TV or VCR remote control (all illustrations allow for use of a converter remote control)
- ability to use timed, multi-channel, multi-event VCR feature
- total signal attenuation (*i.e.* if your system levels are near 0 dBmV and the installation diagram calls for a four-way splitter, your subscriber will get snowy pictures)
- number of *high-quality* A/B switches (yielding 70 to 80 dBs of isolation at minimum) needed
- 0 dBmV is assumed to be the minimum input level for a converter
- mid-UHF converters may not translate all super-band channels to UHF
- VCRs in bypass require high drop levels

Notes on Illustrations — equipment, drop level, signal leakage considerations.

1. Some TV sets are shown with 300 ohm input terminals, others with direct coaxial inputs — either input terminal type is acceptable as far as the diagrams are concerned.

2. If direct connection to external antenna systems is part of the installation scheme, operators *have to* keep potential signal leakage in mind and avoid same with proper A/B switch quality and isolation. Read chapter three in this section — "Ingress/Egress Discussion" before attempting any cable TV installation.

3. If three-way splitters are used, note that the dot in the illustration's splitter denoted the higher level output leg, assuming one leg at -3.5 dB and two legs at -7.0 dB. If the splitter has equal splits or is hooked up differently, the minimum acceptable drop signal level will need to be increased.

4. Where only one input and output cable is shown for a VCR, it is intended to designate the VHF terminals.

5. Presence of cable compatible TVs and VCRs are assumed in "no-converter" hook-ups.

6. It is assumed that most converters do not have a timed channel selection scheme.

7. Only illustration #14 shows two TV sets; other connections can accommodate two TV sets by the addition of a 2-way splitter at the drop.

Background on Terms used in Illustrations' Text

ALLOWS — assumes that **simultaneous** TV and VCR use (to a greater or lesser degree of access to a full-range of paid-for cable programming) is the subscriber's aim

ANY CHANNEL — "any" = whatever channels a subscriber's home equipment (TV, VCR, converter) is capable of receiving and that a subscriber has paid for

SCRAMBLED — a signal that requires a descrambler

NON-SCRAMBLED — a signal that is never scrambled; sent in the clear

OFF-AIR — channels received via an external TV antenna, not delivered via "over-the-wire" cable TV service

CABLE CHANNELS — any channels delivered via "over-the-wire" cable TV service that a subscriber has paid to receive

RECORDING — videocassette recording

Step 1: The first thing to determine (and then locate in the selection guide) is the **number of converters** needed. For example: a cable system that uses traps will not need converters in the subscribers' homes, nor will a basic-tier subscriber owning a cable-compatible TV and VCR need a converter. The top, left-hand square of the selection guide says "no converter" indicating that the top row of the guide will list all applicable illustration numbers.

Step 2: The second thing to determine is the desirability of keeping the TV's or VCR's **remote control** feature and to scan the middle or right-hand columns of the selection guide according to that choice. (All illustrations allow for use of a converter remote control). For example: if one converter is used and the TV and VCR do not have a remote control you would look at the rows adjacent to the "one converter" box and find that illustration #s 7, 1, 3, 8 and 10 would all fit these requirements.

Step 3: You can also determine the importance of full-range-of-service, **simultaneous TV viewing and VCR recording** and find which TV remote control column subset lists the preferred options. For example: if I wanted to be able to watch any channel while my VCR recorded either the program I was viewing or a program on another channel, I would know that the set-ups in illustrations 18 through 22, and 27 would allow that option.

Step 4: Finally, to determine which illustrations do not allow use of a VCR's timed and sequential **multi-channel recording** feature, note which illustration numbers are circled. For example: illustration #21.

Illustration Selection Guide





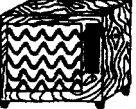

















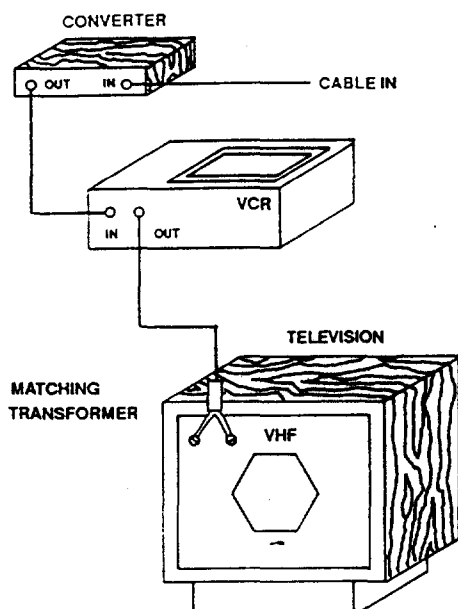
# of required converters	precludes use of TV remote 	PRESERVES use of TV remote for NON-SCRAMBLED CHANNELS ONLY 
* 		12, 13, 17, 25
	can record  while viewing same  7	5, 6, 9, 16, 24
	can record  while viewing   23, 26	
	can record  while viewing   3, 8, 10	11, 15
 	can record  or   14	while viewing the same or another channel 18, 19, 20,  , 22, 27
Notes: * (no converter) i.e. a trap system or else presence of cable-compatible TV & VCR — all configurations allow use of converter remotes — most popular illus.: 1,2,4,5,7,12	Key  scrambled channels  non-scrambled channels  TV's remote control  does not permit timed, multi-event multi-channel VCR recordings	

ILLUSTRATION # 1



Allows:

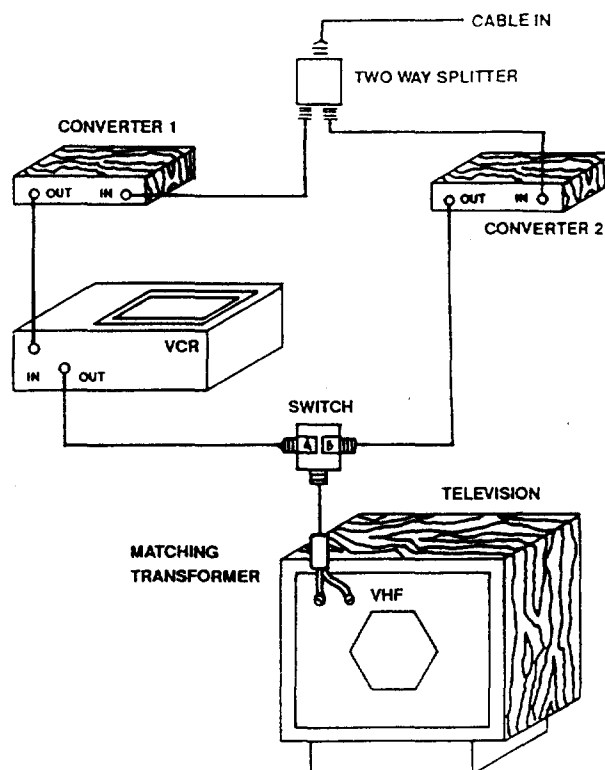
- recording of ANY channel, while viewing the SAME channel

Precludes:

- timed, multi-channel, multi-event recording (i.e. ability to program the VCR to record a movie on channel 5 at 6 p.m., and then a second program on channel 26 at 8 p.m.)
- channel selection by the TV remote control
- channel selection by the VCR remote control

NECESSARY DROP LEVEL: 0dBmV

ILLUSTRATION # 2



Allows:

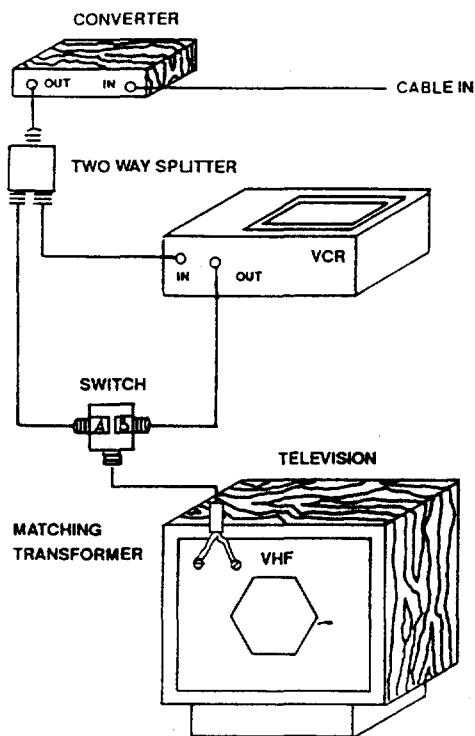
- recording of ANY channel, while viewing ANY channel

Precludes:

- timed, multi-channel, multi-event recording (i.e. ability to program VCR to record a movie on channel 5 at 6 p.m., and then a second program on channel 26 at 8 p.m.)
- channel selection by the TV remote control
- channel selection by the VCR remote control

NECESSARY DROP LEVEL: +3.5dBmV

ILLUSTRATION # 3



for VCRs without bypass circuitry

Allows:

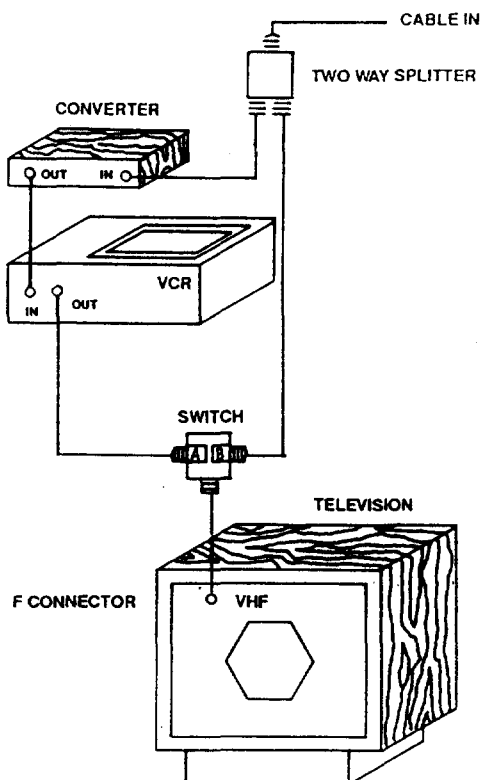
- recording of ANY channel, while viewing SAME channel

Precludes:

- timed, multi-channel, multi-event recording (i.e. ability to program the VCR to record a movie on channel 5 at 6 p.m., and then a second program on channel 26 at 8 p.m.)
- channel selection by the TV remote control
- channel selection by the VCR remote control

NECESSARY DROP LEVEL: 0dBmV

ILLUSTRATION # 4



Allows:

- recording of ANY channel, while viewing ANY NON-SCRAMBLED channel
- *use of TV remote control for non-scrambled channels (only)

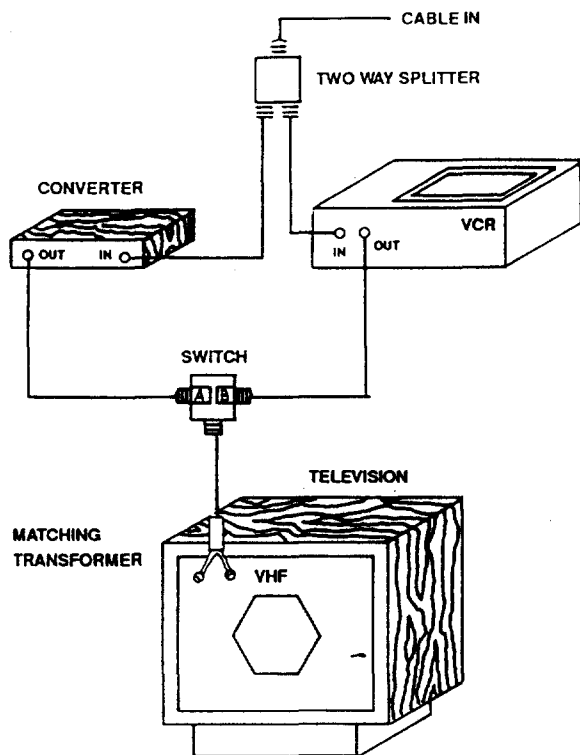
Precludes:

- timed, multi-channel, multi-event recording (i.e. ability to program the VCR to record a movie on channel 5 at 6 p.m., and then a second program on channel 26 at 8 p.m.)
- channel selection by the TV remote control
- recording of non-scrambled channel while viewing a non-scrambled channel

Note: scrambled channels can only be viewed through converter and VCR

NECESSARY DROP LEVEL: +3.5dBmV

ILLUSTRATION # 5



Allows:

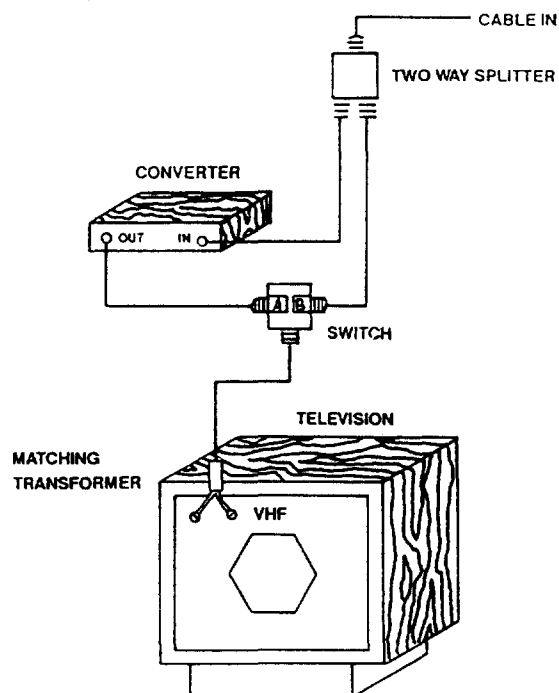
- recording of (ONLY) NON-SCRAMBLED channel, while viewing ANY channel
- timed, multi-channel, multi-event recording (i.e. ability to program the VCR to record a movie on channel 5 at 6 p.m., and then a second program on channel 26 at 8 p.m.) of NON-SCRAMBLED CHANNELS ONLY
- full use of the TV remote control—WITH VCR IN BYPASS MODE (+8.5dBmV drop level required)
- full use of the VCR remote control

Precludes:

- recording of scrambled channels

NECESSARY DROP LEVEL: +3.5dBmV

ILLUSTRATION # 6

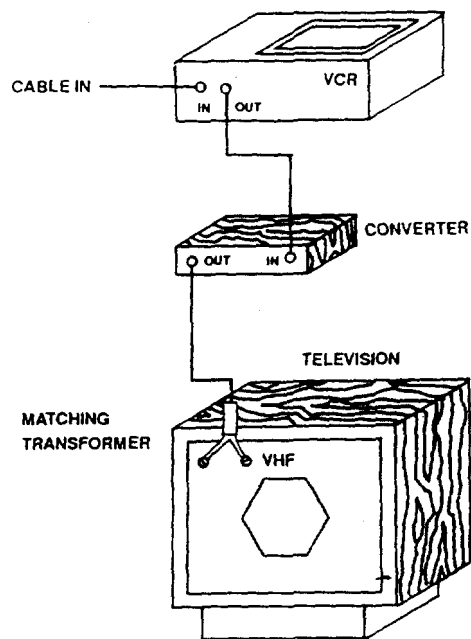


Allows:

- viewing of ANY channel
- use of the TV remote control (for NON-SCRAMBLED CHANNELS ONLY)

NECESSARY DROP LEVEL: +3.5dBmV

ILLUSTRATION # 7



Allows:

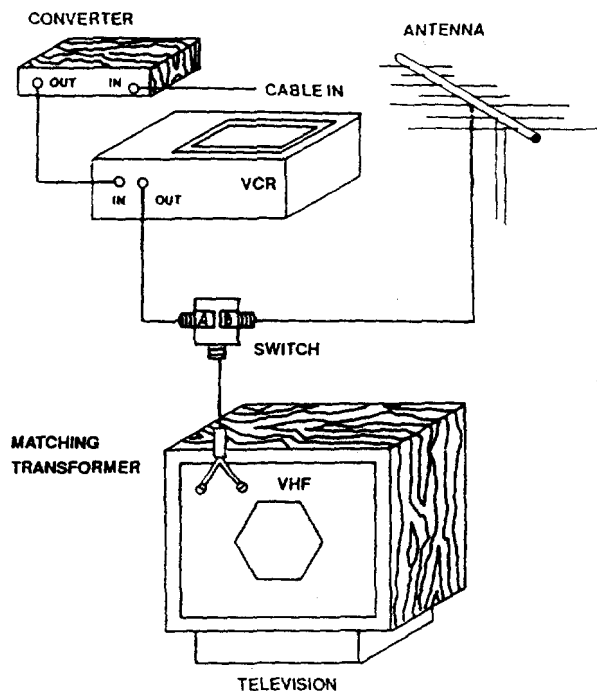
- recording of ONLY NON-SCRAMBLED channels, while viewing ANY channel
- timed, multi-channel, multi-event recording (i.e. ability to program VCR to record a movie on channel 5 at 6 p.m., and then a second program on channel 26 at 8 p.m.) of OFF-AIR CHANNELS ONLY
- full use of the VCR remote control

Precludes:

- channel selection by the TV remote control
- may preclude use of converter's remote control

NECESSARY DROP LEVEL: 0dBmV

ILLUSTRATION # 8



Allows:

- record of ANY channel, while viewing THE SAME CABLE channel or ANY OFF-AIR CHANNEL

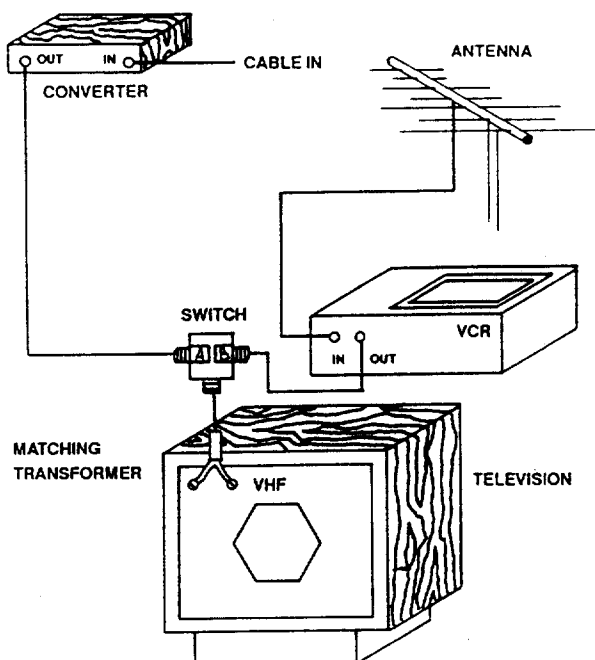
Precludes:

- timed, multi-channel, multi-event recording (i.e. ability to program the VCR to record a movie on channel 5 at 6 p.m., and then a second program on channel 26 at 8 p.m.)
- channel selection by the TV remote control
- channel selection by the VCR remote control

Note: requires high-isolation A/B switch

NECESSARY DROP LEVEL: 0dBmV

ILLUSTRATION # 9



Allows:

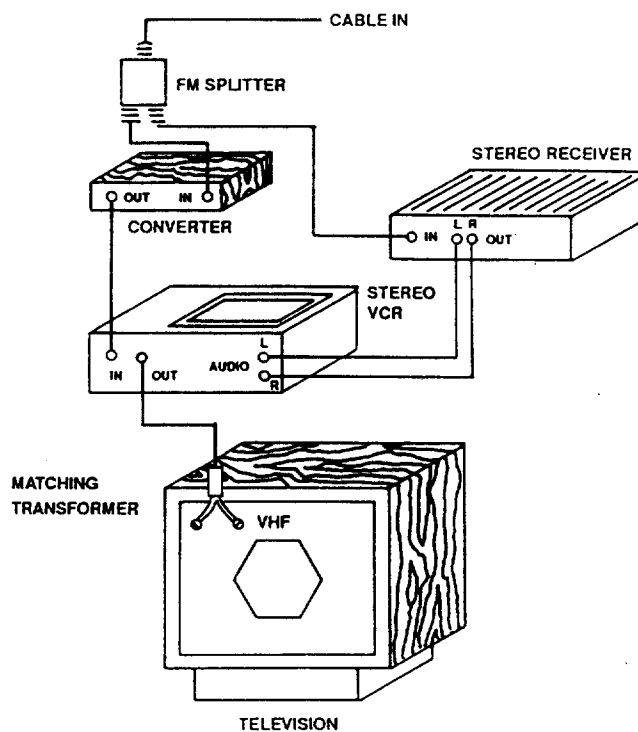
- recording of OFF-AIR channel, while viewing ANY OFF-AIR or ANY CABLE channel
- timed, multi-channel, multi-event recording (i.e. ability to program VCR to record a movie on channel 5 at 6 p.m., and then a second program on channel 26 at 8 p.m.) of OFF-AIR CHANNELS ONLY
- full use of the VCR remote control

Precludes:

- channel selection by the TV remote control
- recording of any cable channel

NECESSARY DROP LEVEL: 0dBmV

ILLUSTRATION # 10



Allows:

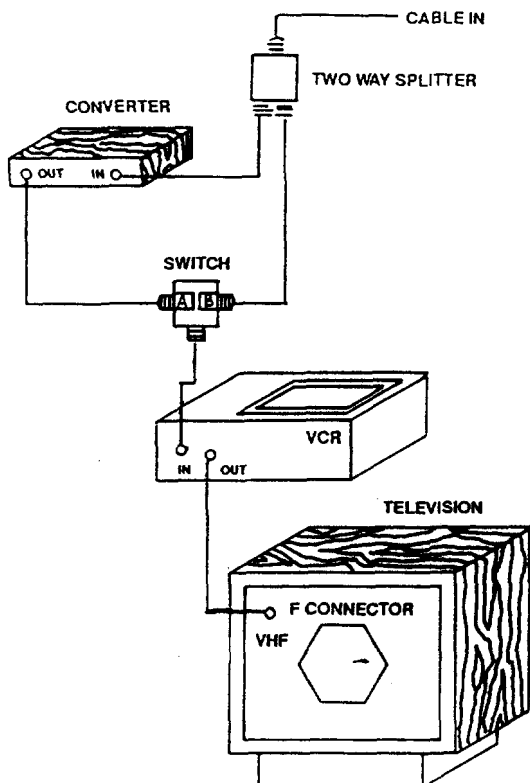
- recording of ANY channel, while viewing THE SAME channel
- recording of simulcast audio

Precludes:

- timed, multi-channel, multi-event recording (i.e. ability to program VCR to record a movie on channel 5 at 6 p.m., and then a second program on channel 26 at 8 p.m.)
- channel selection by the TV remote control
- channel selection by the VCR remote control

NECESSARY DROP LEVEL: +1dBmV

ILLUSTRATION # 11



Allows:

- recording of ONLY NON-SCRAMBLED channels, while viewing ANY NON-SCRAMBLED channel
- recording of scrambled channel while viewing same channel

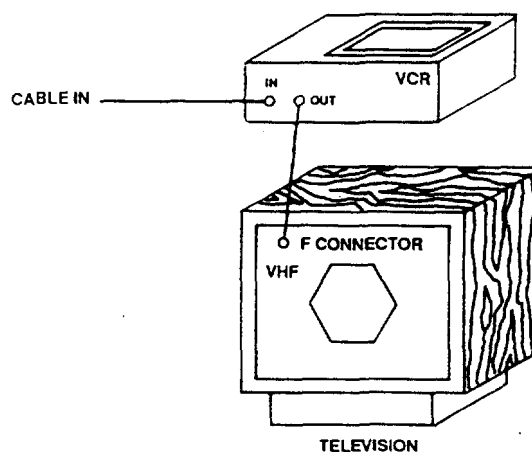
Also allows (for NON-SCRAMBLED CHANNELS ONLY):

- timed, multi-channel, multi-event recording (i.e. ability to program VCR to record a movie on channel 5 at 6 p.m., and then a second program on channel 26 at 8 p.m.) of OFF-AIR CHANNELS ONLY
- channel selection by the TV remote control
- channel selection by the VCR remote control

Note: only real benefit of this connection appears to be use of VCR remote and independent timed, multi-channel, multi-event recording

NECESSARY DROP LEVEL: +3.5dBmV

ILLUSTRATION # 12



Allows:

- recording of ANY channel, while viewing ANY channel
- timed, multi-channel, multi-event recording (i.e. can program VCR to record a movie on channel 5 at 6 p.m., and then a second program on channel 26 at 8 p.m.)
- full use of the TV remote control
- full use of the VCR remote control

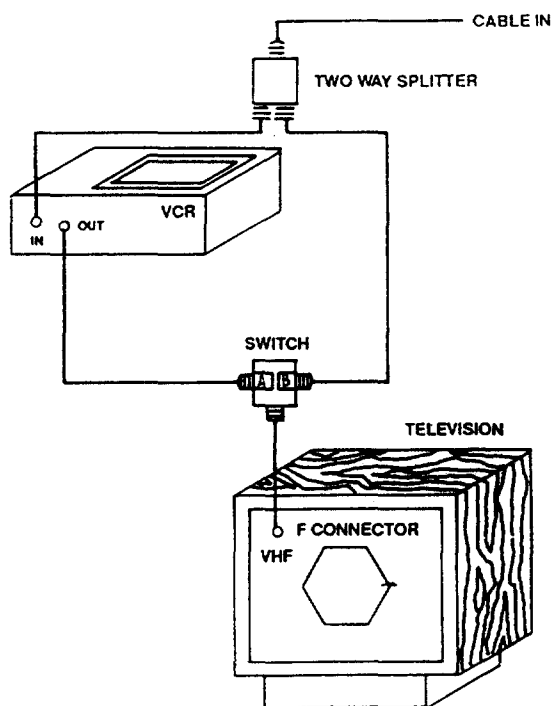
Precludes:

- non-cable compatible VCRs

Note: assumes all channels are non-scrambled

NECESSARY DROP LEVEL: +5dBmV

ILLUSTRATION # 13



Allows:

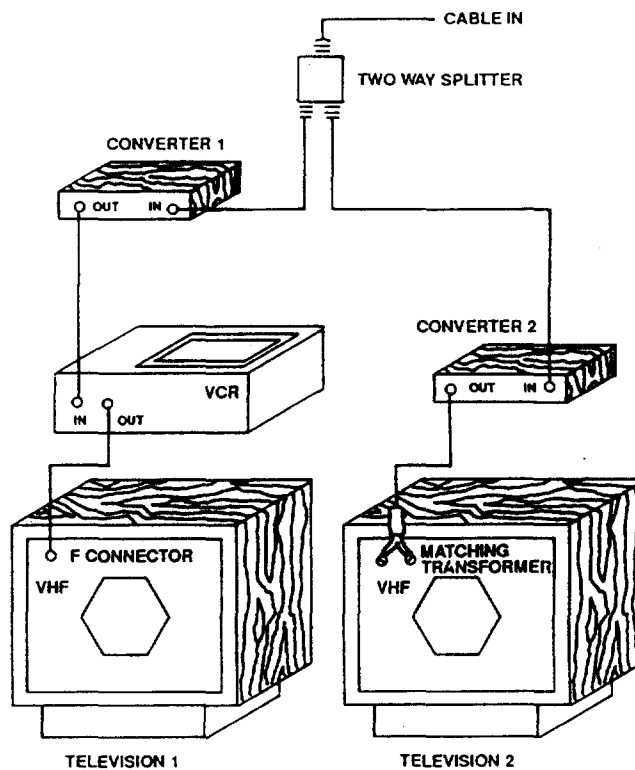
- recording of ANY channel, while viewing ANY channel
- timed, multi-channel, multi-event recording (i.e. ability to program VCR to record a movie on channel 5 at 6 p.m., and then a second program on channel 26 at 8 p.m.)
- full use of the TV remote control
- full use of the VCR remote control

Assumes:

- VCR does not have a bypass or the bypass has high insertion loss
- all channels are non-scrubbed

NECESSARY DROP LEVEL: +3.5 dBmV

ILLUSTRATION # 14



Allows:

- recording of ANY channel, while viewing SAME channel on first set
- viewing of any channel on the second set

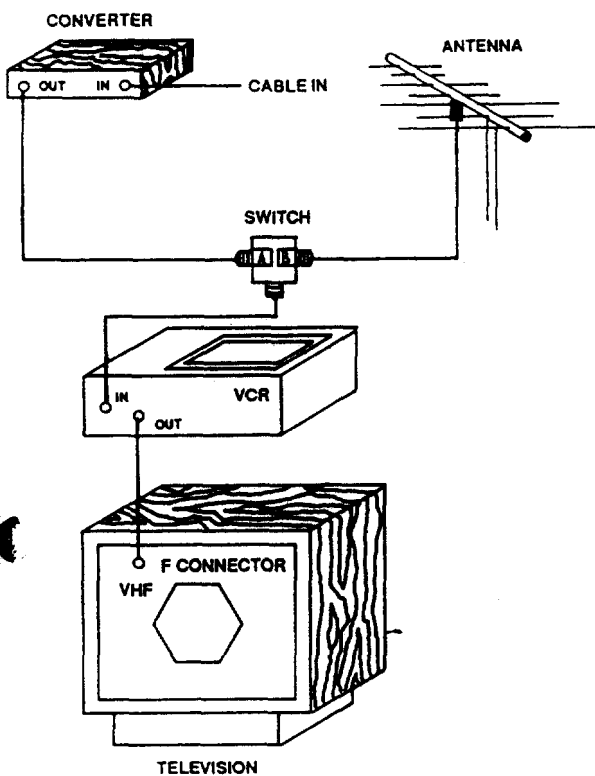
Precludes:

- timed, multi-channel, multi-event recording (i.e. ability to program VCR to record a movie on channel 5 at 6 p.m., and then a second program on channel 26 at 8 p.m.)
- channel selection by the TV remote control

Note: this is the only illustration for two TV sets; other connections can accommodate two sets by the addition of a two-way splitter at the drop.

NECESSARY DROP LEVEL: +3.5 dBmV

ILLUSTRATION # 15



Allows:

- recording of ANY CABLE CHANNEL, while viewing THE SAME CABLE CHANNEL
- recording of any off-air channel, while viewing any off-air channel

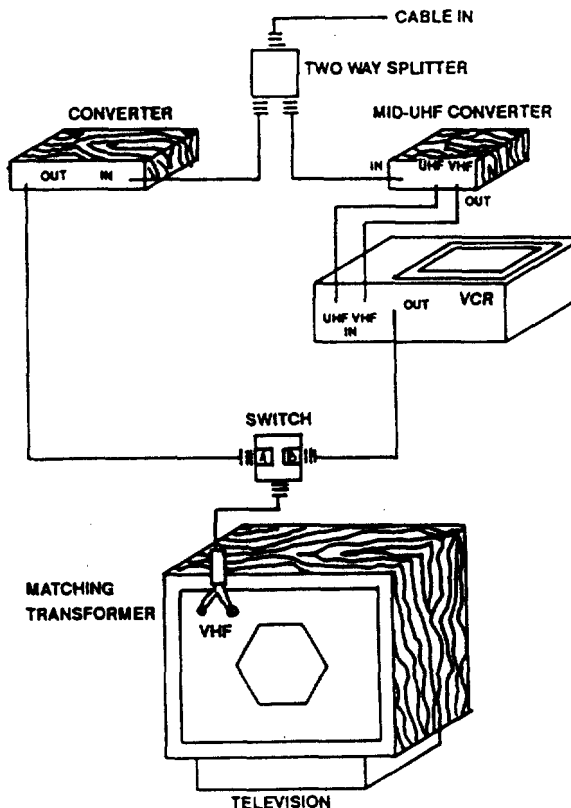
Also allows (for OFF-AIR CHANNELS ONLY):

- timed, multi-channel, multi-event recording (i.e. ability to program VCR to record a movie on channel 5 at 6 p.m., and then a second program on channel 26 at 8 p.m.)
- channel selection by the TV remote control
- channel selection by the VCR remote control

Precludes (for CABLE CHANNELS):

- timed, multi-channel, multi-event recording, use of TV or VCR remotes
- NECESSARY DROP LEVEL: 0dBmV

ILLUSTRATION # 16



Allows:

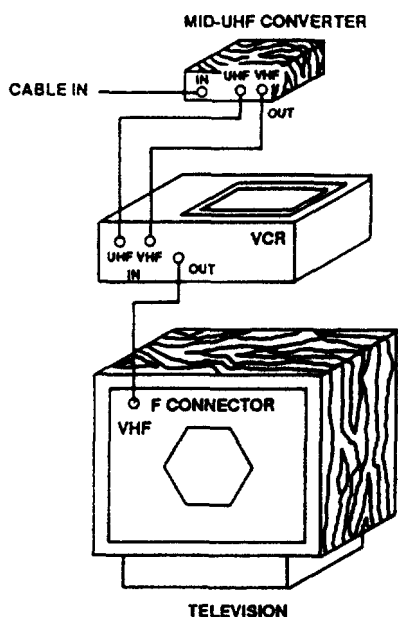
- recording of ONLY NON-SCRAMBLED channels, while viewing ANY channel

Also allows (except when using the converter):

- timed, multi-channel, multi-event recording (i.e. ability to program the VCR to record a movie on channel 5 at 6 p.m., and then a second program on channel 26 at 8 p.m.)
- full use of the TV remote control
- full use of the VCR remote control

NOTE: allows for viewing of all channels on a non-cable ready TV
NECESSARY DROP LEVEL: +3.5dBmV

ILLUSTRATION # 17



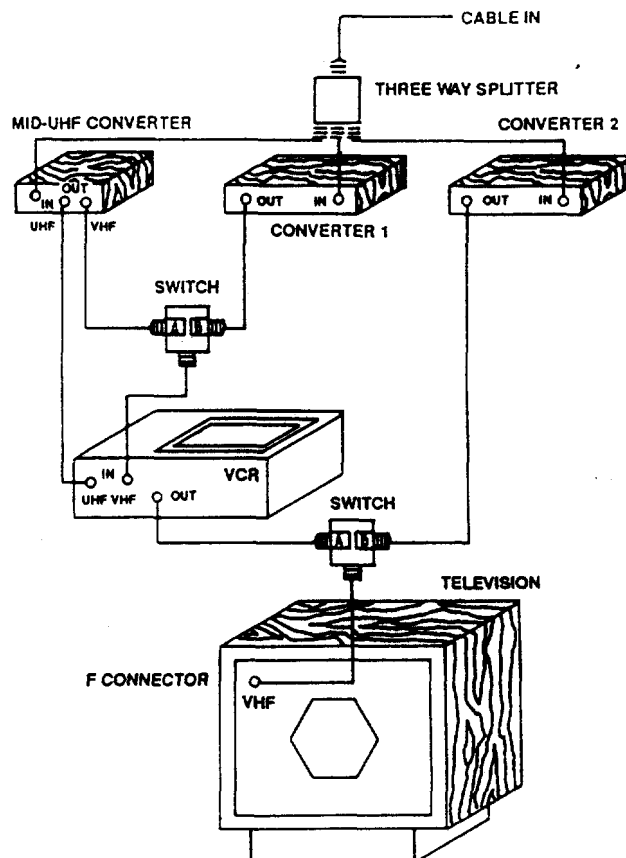
Allows:

- recording of NON-SCRAMBLED channels, while viewing ONLY NON-SCRAMBLED channels
- timed, multi-channel, multi-event recording (i.e. ability to program VCR to record a movie on channel 5 at 6 p.m., and then a second program on channel 26 at 8 p.m.)
- full use of the TV remote control
- full use of by the VCR remote control

Now: This illustration is useful if the non-cable compatible VCR has a remote control but the TV doesn't. Illustration #25 is superior for VCRs with bypass circuitry

NECESSARY DROP LEVEL: +5dBmV

ILLUSTRATION # 18



Allows:

- recording of ANY channel, while viewing ANY channel
- timed, multi-channel, multi-event recording (i.e. ability to program VCR to record a movie on channel 5 at 6 p.m., and then a second program on channel 26 at 8 p.m.) of NON-SCRAMBLED CHANNELS ONLY

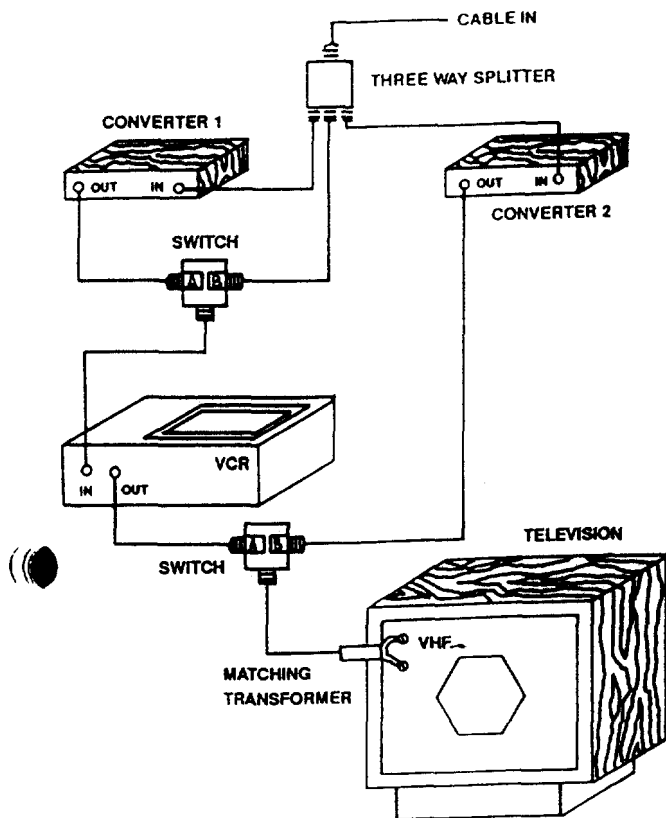
Precludes:

- channel selection by the TV remote control
- channel selection by the VCR remote control

Now: use of converter remote control will affect both converters simultaneously

NECESSARY DROP LEVEL: +7dBmV

ILLUSTRATION # 19



Allows:

- recording of ANY channel, while viewing ANY channel

Allows (when VCR in non-converter, bypass mode):

- timed, multi-channel, multi-event recording (i.e. ability to program VCR to record a movie on channel 5 at 6 p.m., and then a second program on channel 26 at 8 p.m.)
- (NON-SCRAMBLED CHANNELS ONLY)
- channel selection by the TV remote control
- channel selection by the VCR remote control

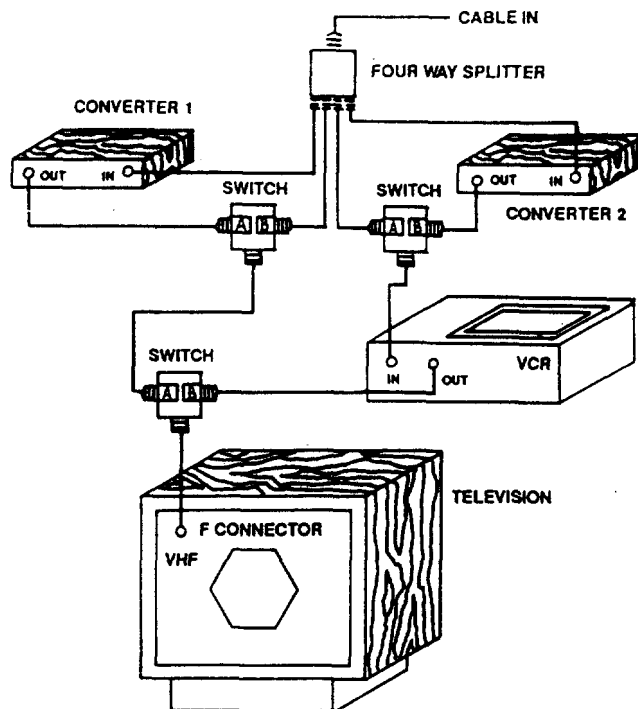
Precludes (on scrambled channels):

- timed multi-channel, multi-event recording, use of TV or VCR remotes

Note: use of converter remote control will affect both converters simultaneously

NECESSARY DROP LEVEL: +7dBmV

ILLUSTRATION # 20



Allows:

- recording of ANY channel, while viewing ANY channel

Also allows (for NON-SCRAMBLED CHANNELS ONLY):

- timed, multi-channel, multi-event recording (i.e. ability to program VCR to record a movie on channel 5 at 6 p.m., and then a second program on channel 26 at 8 p.m.)
- full use of the TV remote control
- full use of the VCR remote control

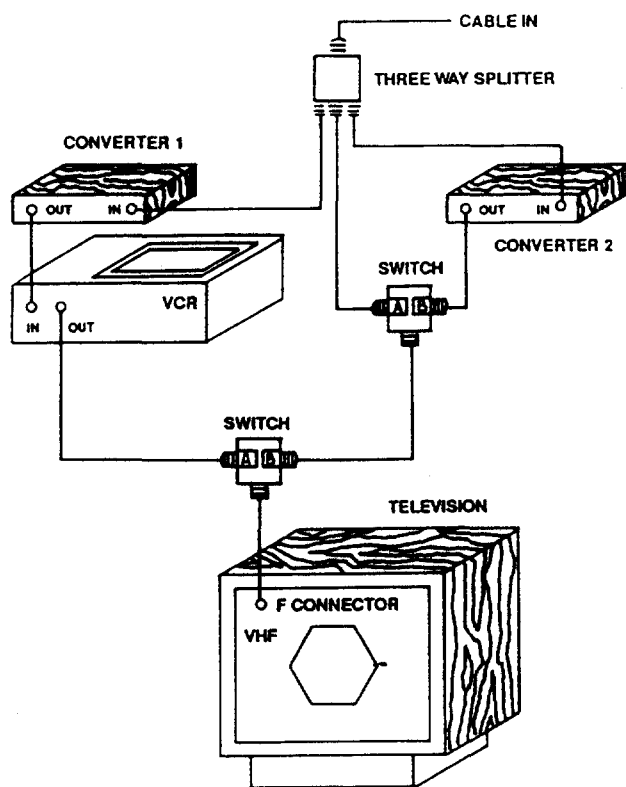
Precludes:

- timed multi-channel, multi-event recording, use of TV or VCR remote control on SCRAMBLED CHANNELS

Note: converter's remote control will affect both converters simultaneously

NECESSARY DROP LEVEL: +7dBmV

ILLUSTRATION # 21



Allows:

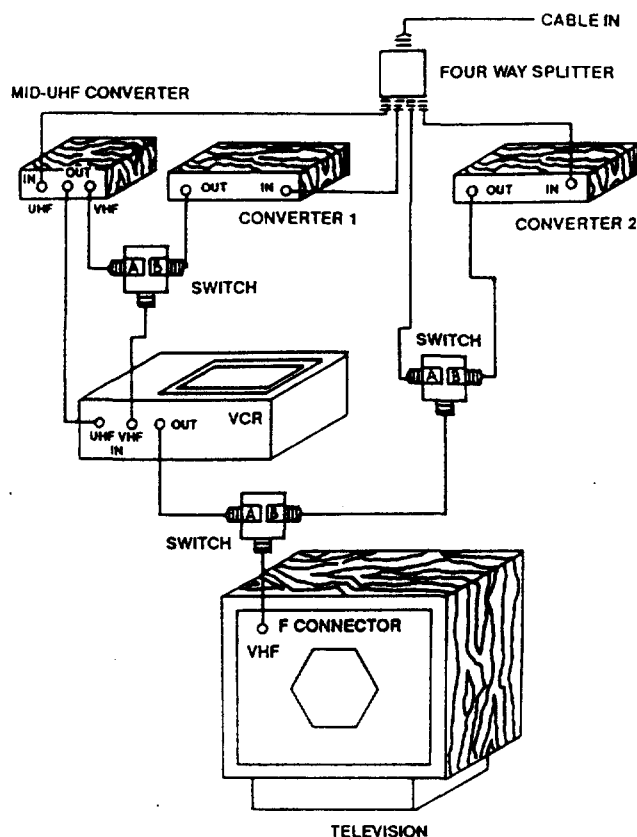
- recording of ANY channel, while viewing ANY channel
- full use of the TV remote control

Precludes:

- timed, multi-channel, multi-event recording (i.e. ability to program VCR to record a movie on channel 5 at 6 p.m., and then a second program on channel 26 at 8 p.m.)
- use of TV remote control for SCRAMBLED CHANNELS
- channel selection by the VCR remote control

Note: converter's remote control will affect both converters simultaneously
NECESSARY DROP LEVEL: +7dBmV

ILLUSTRATION # 22



Allows:

- recording of ANY channel, while viewing ANY channel

Also allows (for NON-SCRAMBLED CHANNELS ONLY):

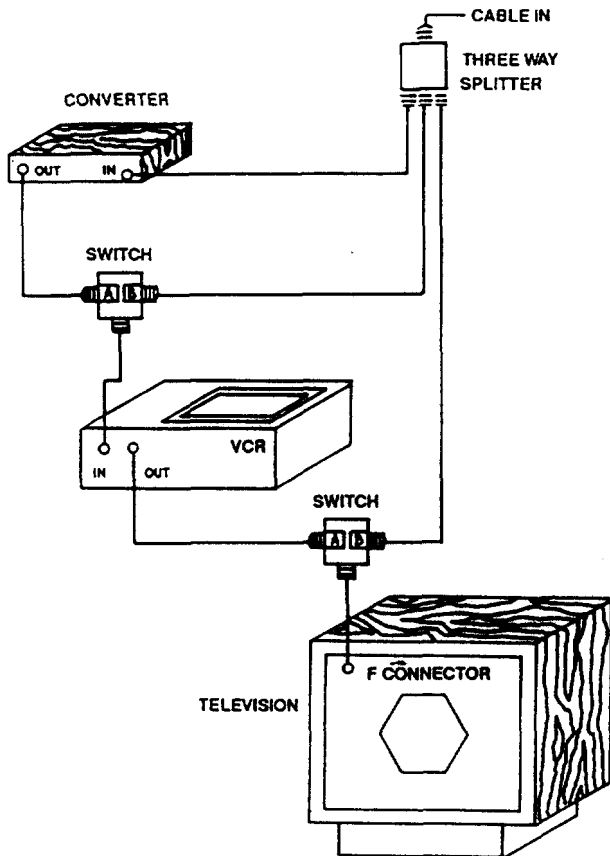
- timed, multi-channel, multi-event recording (i.e. ability to program VCR to record a movie on channel 5 at 6 p.m., and then a second program on channel 26 at 8 p.m.)
- full use of the TV remote control
- full use of by the VCR remote control

Precludes:

- timed multi-channel recording, use of the TV or VCR remote control on SCRAMBLED CHANNELS

Note: converter's remote control will affect both converters simultaneously
NECESSARY DROP LEVEL: +7dBmV

ILLUSTRATION # 23



Allows:

- recording of ANY channel, while viewing A NON-SCRAMBLED channel

Also allows (for NON-SCRAMBLED CHANNELS ONLY):

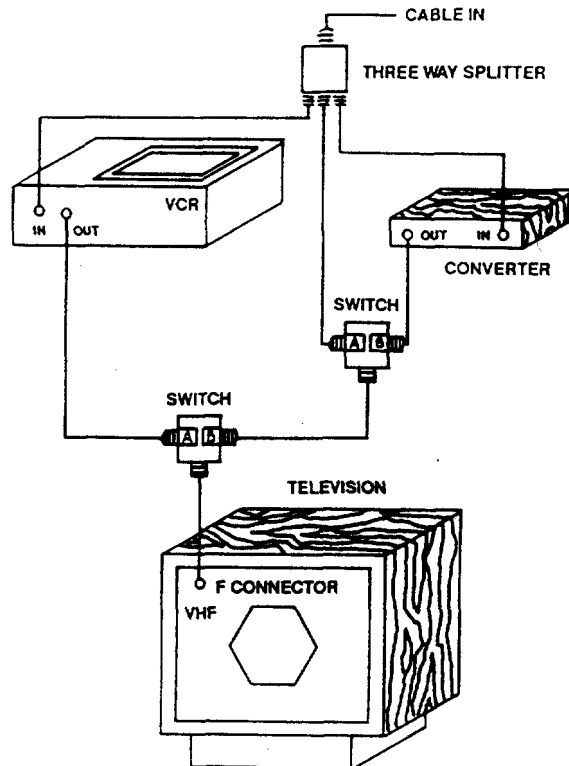
- timed, multi-channel recording (i.e. can program VCR to record a movie on channel 5 at 6 p.m., and then a second program on channel 26 at 8 p.m.)
- full use of the TV remote control
- full use of the VCR remote control

Precludes:

- timed multi-channel recording, use of TV or VCR remote control for SCRAMBLED CHANNELS

NECESSARY DROP LEVEL: +7dBmV

ILLUSTRATION # 24



Allows:

- recording of A NON-SCRAMBLED channel, while viewing ANY channel

Also allows (for NON-SCRAMBLED CHANNELS ONLY):

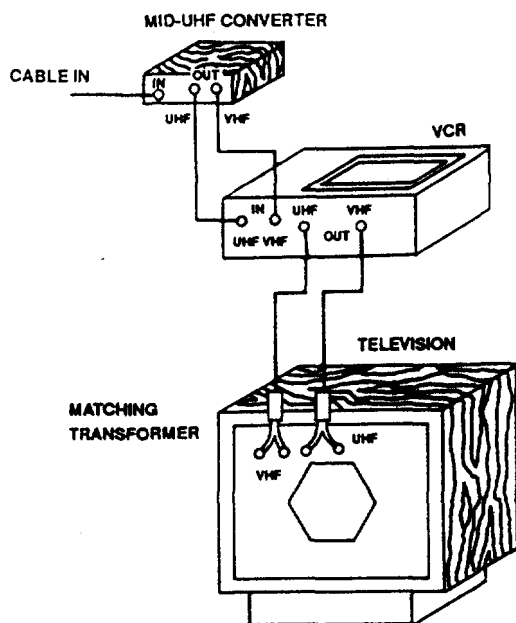
- timed, multi-channel recording (i.e. ability to program VCR to record a movie on channel 5 at 6 p.m., and then a second program on channel 26 at 8 p.m.)
- full use of the TV remote control
- full use of the VCR remote control

Precludes:

- timed multi-channel, multi-event recording, use of TV or VCR remote control for SCRAMBLED CHANNELS
- recording of scrambled channels

NECESSARY DROP LEVEL: +7dBmV

ILLUSTRATION # 25



Allows:

- recording of NON-SCRAMBLED channel, while viewing A NON-SCRAMBLED channel

Also allows (for NON-SCRAMBLED CHANNELS ONLY):

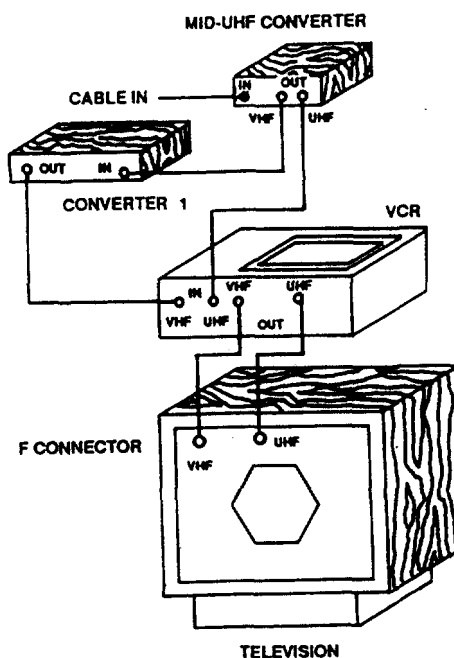
- timed, multi-channel, multi-event recording (i.e. ability to program VCR to record a movie on channel 5 at 6 p.m., and then a second program on channel 26 at 8 p.m.)
- full use of the TV remote control
- full use of the VCR remote control

Precludes:

- recording of scrambled channel while viewing a scrambled channel
- timed multi-channel, multi-event recording, use of TV or VCR remote control on SCRAMBLED CHANNELS

NECESSARY DROP LEVEL: +3.5dBmV

ILLUSTRATION # 26



Allows:

- recording of ANY channel, while viewing A NON-SCRAMBLED channel

Also allows (for NON-SCRAMBLED CHANNELS ONLY):

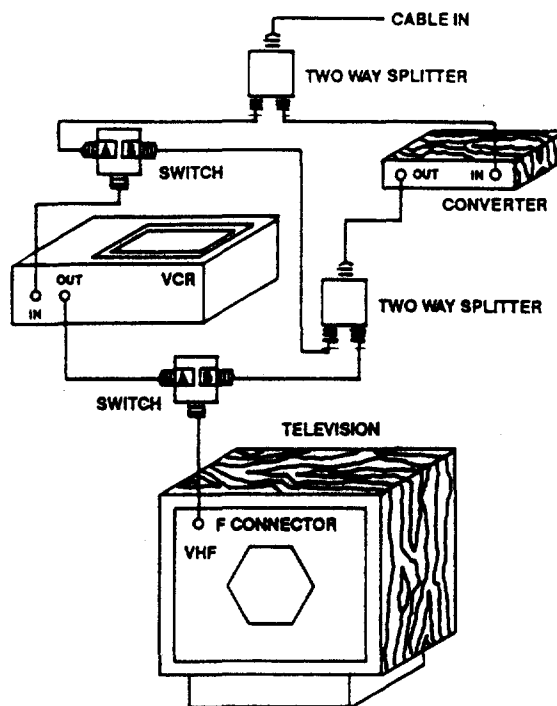
- timed, multi-channel, multi-event recording (i.e. ability to program VCR to record a movie on channel 5 at 6 p.m., and then a second program on channel 26 at 8 p.m.)
- full use of the TV remote control
- full use of the VCR remote control

Precludes:

- timed multi-channel, multi-event recording, use of TV or VCR remote control on SCRAMBLED CHANNELS

NECESSARY DROP LEVEL: +0dBmV

ILLUSTRATION # 27



Allows:

- recording of ANY channel, while viewing THE SAME channel
- recording of ANY channel, while viewing a NON-SCRAMBLED channel
- recording of a NON-SCRAMBLED channel, while viewing ANY channel

Also allows (for NON-SCRAMBLED CHANNELS ONLY):

- timed, multi-channel, multi-event recording (i.e. ability to program VCR to record a movie on channel 5 at 6 p.m., and then a second program on channel 26 at 8 p.m.)
- full use of the TV remote control
- full use of the VCR remote control

Precludes:

- timed multi-channel, multi-event recording, use of TV or VCR remote control on SCRAMBLED CHANNELS

NECESSARY DROP LEVEL: +7dBmV

Chapter Three-Ingress/Egress Discussion

Analysis of Ingress/Egress Issues in the Home:

Ingress and egress can be found at any device between the cable drop and the viewer, including the TV receiver itself. Ingress, also known as direct pickup or DPU, can be defined as any undesirable signal induced on the cable from an electro-magnetic environment outside the cable system. Egress is defined as any signal originating within the cable being radiated to the outside environment from the cable or any device connected to it.

Ingress

Ingress is not limited to the near proximity of TV transmitting sites, it has been observed more than 50 miles from the source of the signal. Sources of ingress can be many, but high power TV transmitting stations, amateur radio and private and public safety land mobile radio operations are the most common sources of ingress. Field intensities in excess of 1 volt/meter have been recorded within two miles of TV stations. Cable channels 2-13 and 18-21 are most often affected. Early TV receivers offered virtually no protection from ingress; this led cable operators to use converters to overcome the effects of DPU.

More recently, TV receiver manufacturers began offering "cable-ready" receivers for sale; these are distinguished by the ability to tune the unique cable channels in the mid and super bands. While the 300 Ohm twinlead, used between the antenna terminals and the tuner in earlier sets, was often replaced by F-fittings and coaxial cable, the shielding was often not adequate to operate satisfactorily in most urban environments.

A test to measure the amount of ingress has been developed. All connections are removed from the device to be tested. A signal level meter is connected to the input connector of the device. The level of ingress can be measured directly on the signal level meter while the tuner on the device under test is operated over all channels. The highest level observed should be recorded; the relative impairment can be determined by taking the ratio of signal on the cable to the level recorded from the meter. For example, if the signal from the cable is 0 dBmV and the level recorded from the meter is -30 dBmV, the Carrier-to-Ingress ratio is 30 dB. If the interfering signal is another TV signal, the interference should be suppressed at least 45-50 dB; if the interfering signal occupies a narrow band of frequencies, such as from a two-way radio, the interference should be suppressed at least 55-60 dB.

Measurements like those just described have been made on 1984 and 1985 model TV receivers, VCRs and CATV converters. The ambient field intensity ranged from 133 mV/m to 1.2 V/m. Ingress on the TV receivers ranged from -44 dBmV to -2 dBmV, VCRs ranged from -30 dBmV to -20 dBmV and CATV converters ranged from -46 dBmV to -32 dBmV. In spite of the foregoing, experience has shown VCRs are more likely to experience ingress as a result of their poorer shielding integrity. Older receiving equipment,

especially that employing 300 Ohm twinlead for the antenna connection, experiences ingress to a much greater degree. Levels from nearby transmitters have been recorded as high as +50 dBmV on some equipment. FM tuners which have built-in antennas, or are coupled to the power line for an antenna, are especially prone to high levels of ingress. When connected to a cable system, this equipment causes back-feeding of the signals into the cable system. The EIA/NCTA Joint Engineering Committee Interface Working Group is expected to issue an interim standard which will increase the field intensity in which TV receiving equipment is to operate satisfactorily from 100 mV/m to 1 V/m.

In some instances, ingress in the home has been so severe that not only is the affected subscriber's viewing disrupted, but signals are back-fed into the cable distribution system. In these cases, everyone downstream from the affected subscriber also experiences the effects of ingress. In these cases, the operator will often try to use a converter as an isolation device to prevent back-feeding; where this is not practical, special amplifiers which exhibit good back-front isolation can be installed in the line to reduce or eliminate back-feeding.

CATV operators selecting components for installation between the subscriber tap and the TV receiver should take care to select products with adequate protection from the effects of ingress. In addition to the usual care in choosing cable and connectors, the operator should also take care in selecting A-B switches, two-way splitters, VCR switch units and converters.

Ingress can occur from standard broadcast radio stations operating in the 550-1620 KHz band. This ingress can be exacerbated when CATV distribution and drop cable shields act like long wire antennas increasing signal intensity at the connected devices. Interference has been observed in both TV sets and VCRs. Although this type of interference is hard to eliminate, its effects can be minimized by good local grounds at the affected equipment.

Egress

Egress can result from inadequate shielding, either from equipment provided by the cable operator or from subscriber-owned equipment. In general, emissions from CATV systems must be limited to 20 μ V/m at three meters. Any operator using channels in the aeronautical bands (108-137 MHz and 225-400 MHz) is required to monitor all portions of the cable system annually; any egress in excess of 20 μ V/m must be identified and corrected. Under certain conditions and after 1990, operators must monitor all portions of the system on a quarterly basis.

The FCC Rules assign responsibility for egress from cable systems and subscriber-owned equipment connected to it as follows:

76.617 Responsibility for receiver-generated interference

Interference generated by a radio or television receiver shall be the responsibility of the receiver

operator in accordance with the provisions of Part 15, Subpart C, of this chapter: Provided, however, that the operator of a cable television system to which the receiver is connected shall be responsible for the suppression of receiver-generated interference that is distributed by the system when the interfering signals are introduced into the system at the receiver.

Even though the subscriber might be responsible for correcting problems with subscriber-owned equipment, the cable operator is faced with the often difficult task of isolating the source of egress. If the cause of the egress is inadequate shielding in a TV receiver or VCR, the owner is often precluded from using the equipment as it was intended; e.g. a "cable-ready" TV receiver or VCR that cannot be connected directly to the cable. Generally, as ambient signal levels increase, ingress will become a problem before egress will. This is true because taps and splitters used by the cable industry have inherent isolation, usually at least 20 dB. Therefore, DPU will become visible on a customer's TV set before it gets high enough to affect the neighbors. Systems will sometimes provide converters to some but not all subscribers. Those subscriber's TV sets not using a converter are usually connected directly to the cable. In cases where shielding in the TV sets is poor, cable signals radiated by the TV receivers can and do cause interference to licensed radio services such as amateur radio operators, fire, police and forestry services. CATV maintenance personnel need to be especially vigilant to find and control or eliminate this type of egress. If necessary, the offending drop should be disconnected until the egress can be eliminated.

It should be apparent many people are affected by ingress and egress; the cable operator experiences increased operating costs and deteriorated signal quality. If the offending equipment is relatively new, the dealer often experiences the wrath of a dissatisfied customer. The biggest loser of all is the cable customer who suffers from impaired service, often after paying a premium for special "cable-ready" equipment. If the cooperative efforts of the EIA and NCTA are successful, designers of new equipment will be cognizant of the cable environment and include shielding to make their products immune to the effects of the electro-magnetic environment.

Following, on the next page, is a document which is suitable for use by field personnel who are faced with problem solving when equipment is connected directly to the CATV system. A complete treatment of all problems encountered would be voluminous, so this will only serve as a guide. It does not treat every possible situation which might be encountered.

Technical Guidelines for Direct Connection to Customer Owned Equipment: Introduction

Surveys have shown the number of cable-ready television sets have increased exponentially in recent years; we estimate about one-third of our customers now own a receiver capable to tuning most or all of our non-scrambled

channels. These sets are selling at a rate of 10 million per year. So we expect the number of customers desiring to connect directly to the cable will increase substantially in the next few years. Concurrently, the number of VCRs sold has increased remarkably. CATV converters and converter/descramblers are a barrier to using the features of these consumer devices. We desire to accommodate and aid our customers in using their own equipment to tune CATV channels whenever possible; at the same time the CATV operator can reduce his investment in owning and maintaining converters.

However, in accommodating direct connections to the cable we must establish policies and procedures to protect the quality of the service we provide. These guidelines are intended to protect the customer and the CATV network from service problems and picture impairment which could be caused by the direct connection of inadequately shielded equipment.

While a converter/descrambler or a descrambler will continue to be necessary for anyone receiving scrambled signals, use of plain converters can be reduced and perhaps eliminated in the future. Based on survey data, we believe one-third of our basic customers may not require a converter to receive our service.

Unfortunately, only a few of the cable-ready television receivers and VCRs are completely satisfactory for direct connection to the cable system. While more present day consumer products designated as "cable-ready" can tune most or all CATV channels, few, if any, have adequate shielding for signal ingress and egress. Egress can result in re-radiation of CATV signals in excess of FCC limits. (Section II, chapter one contains definitions and a general discussion of these mechanisms.)

The most common problem results from signals from television stations and mobile radios entering the equipment and disrupting customer viewing. The phenomenon is known as ingress or Direct Pick Up (DPU). Disruption can take two forms: echoes and other interference and/or beats in the connected television set or VCR. This can have an impact on the owner of the equipment. The more disturbing effects occur when DPU is so intense so as to feed DPU back into the cable system from poorly shielded equipment. Not only can this impair reception for the equipment owner, but for every other customer downstream from that location. Diagnosis and elimination of this "back fed" DPU can be very difficult and time consuming, especially if there is more than one location where DPU is being introduced on the system.

It is the purpose of these guidelines to establish procedures to prevent DPU from impairing the viewing for the customer where the direct connection is made, and to prevent DPU from direct connections from back feeding into the cable system.

Many of these situations already exist and the number can be expected to increase as sales of cable compatible television receivers and VCRs continue.

Installation and Maintenance of Basic Service

A. Identification and Prevention of Back Feeding

(1) Discussion

Most CATV passive devices have at least 20 dB isolation between any two ports; this is depicted on Figures 1 and 2.

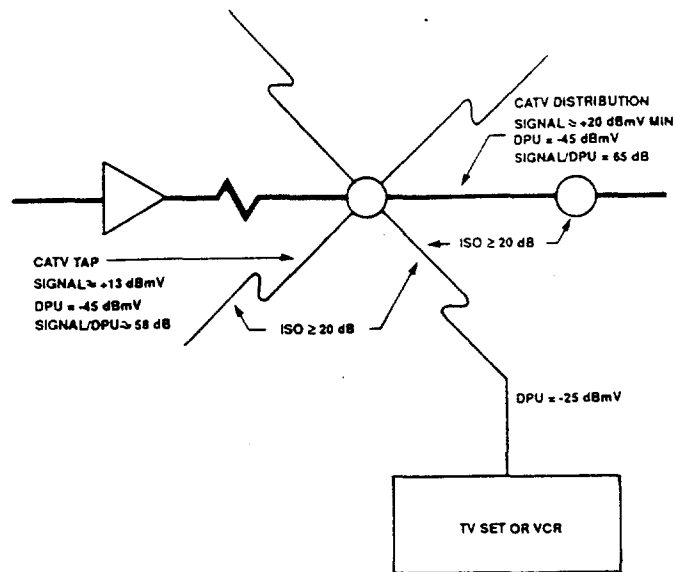


FIGURE 1

TYPICAL TAP ISOLATION

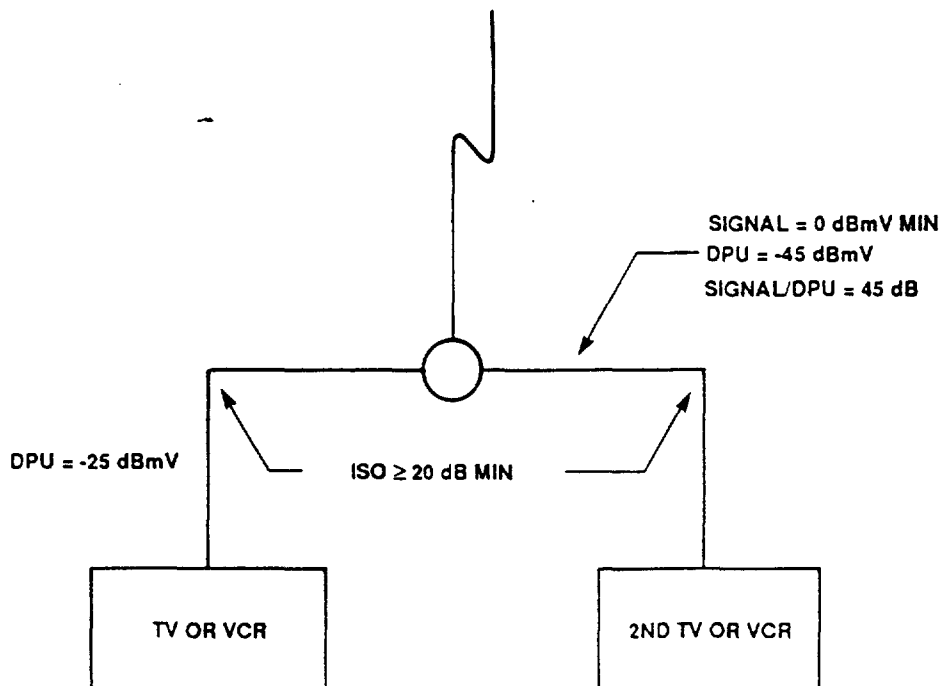


FIGURE 2

TYPICAL SPLITTER ISOLATION

DPU from television stations, which is manifested as a sync bar or echo in the picture, should be suppressed at least 45-50 dB if DPU is not to produce visible echoing. If the passive components provide a minimum of 20 dB isolation, then DPU levels from television sets and VCRs should be less than -25 dBmV. This assumes drop levels are 0 dBmV. Beats caused by other services such as land mobile radios and television stations off frequency from cable channels should be suppressed 50-55 dB if they are not to cause visible beats in the picture. In these cases, levels at receiver and VCR connectors must be less than -30 to -35 dBmV if they are not to cause harmful back feeding.

When DPU at the antenna terminals exceeds the limit, a converter or isolation amplifier is needed to reduce the amplitude of the DPU signal back fed into the CATV system. The amplifier has modest forward gain (approximately 10 dB), but has at least 45 dB attenuation from the output port to the input port. It should be understood, the isolation amplifier only protects the CATV network from back feeding, it will have minimal or no effect in reducing echoing in the receiver or VCR; if echoing is present as a result of DPU in the VCR or receiver, only a converter will eliminate the phenomenon.

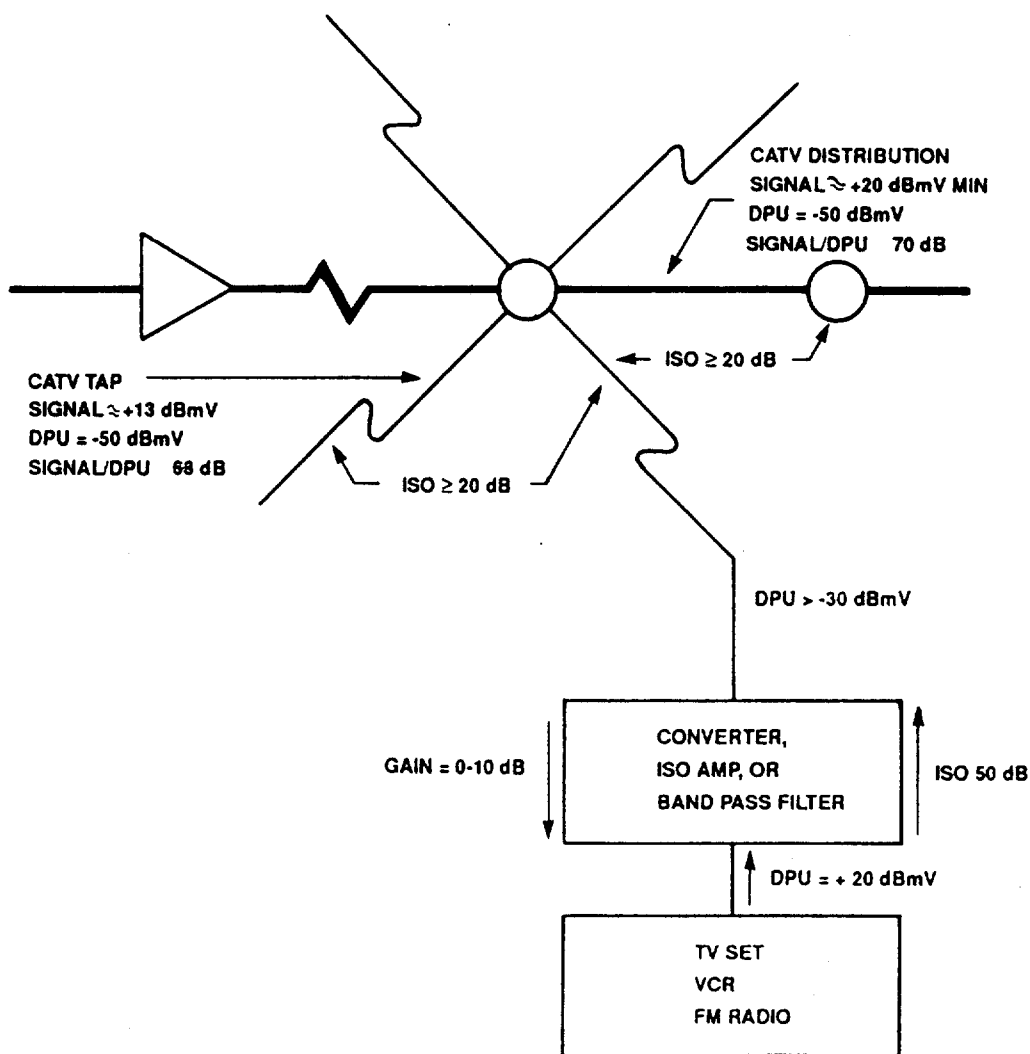


FIGURE 3
ISOLATION AMPLIFIER OR CONVERTER FOR ISOLATION